PATENT ABSTRACTS OF JAPAN

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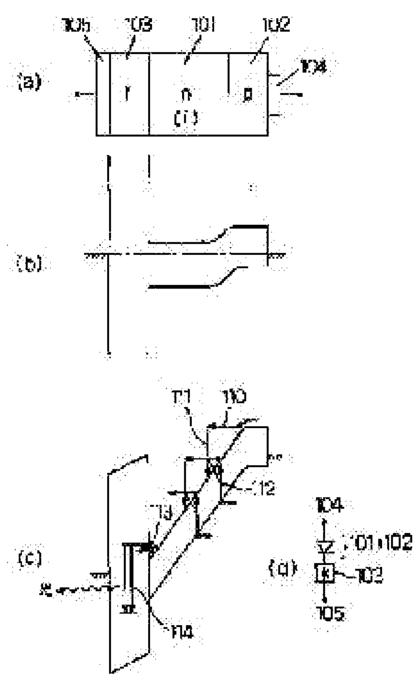
(54) **AVALANCHE LIGHT EMITTING DEVICE**



(57)Abstract:

PURPOSE: To provide a light emission device which shows a sufficient emission luminance comparable to the luminance of a CRT even if a device driving voltage is low.

CONSTITUTION: A p-n-f (or n-p-f) junction is composed of a fluorescent(f) region 103, a first conductivity (n or p) type low impurity concentration first semiconductor region 101 and a second conductivity (p or n) type low impurity concentration second

semiconductor region 102. Electrons (or holes) which are generated by avalanche multiplication created in the p-n junction to which a backward bias is applied rush into the fluorescent material region 103 directly to generate light emission.

CLAIMS

[Claim(s)]

[Claim 1]pnf (or npf) junction is formed in the 2nd semiconductor region of low impurity concentration in the 1st semiconductor region and 2nd electric conduction (p or n) mold of low impurity concentration with a fluorescent substance (f) field and the 1st electric conduction (n or p) mold, an electron (or electron hole) of avalanche multiplication produced by pn junction of reverse bias is direct -- an avalanche luminescent device rushing into said fluorescent substance field and making it emit light.

[Claim 2]A fluorescent substance (f) field and the 1st electric conduction (n.) Or n'pnf (or p'npf) junction is formed with p mold in the 1st semiconductor region and 2nd electric conduction (p or n) mold of low impurity concentration, and is formed in the 3rd semiconductor region of low impurity concentration with the 2nd semiconductor region and 1st electric conduction (n' or p') mold of low impurity concentration, an electron (or electron hole) of avalanche multiplication produced by pn junction of reverse bias is direct -- an avalanche luminescent device rushing into said fluorescent substance field and making it emit light.

[Claim 3]A fluorescent substance (f) field and the 1st electric conduction (n.) With p mold, or the 1st semiconductor region of low impurity concentration and the 2nd electric conduction. (p or n) N'pnf (or P'npf)

junction is formed in the 3rd semiconductor region of low impurity concentration with the 1st electric conduction (N' or P') mold which has bigger bandgap energy than the 2nd semiconductor region and said 2nd semiconductor region of low impurity concentration with a mold, an electron (or electron hole) of avalanche multiplication produced by pn junction of reverse bias is direct -- an avalanche luminescent device rushing into said fluorescent substance field and making it emit light.

[Claim 4]pif (or nif) junction is formed with a fluorescent substance (f) field and an intrinsic electric conduction (i) mold at the 2nd ******** of low impurity concentration in the 1st semiconductor region of low impurity concentration, and an electron hole electric conduction p (or electronic electric conduction n) mold, an electron (or electron hole) of avalanche multiplication produced by pi (or ni) junction of reverse bias is direct -- an avalanche luminescent device rushing into said fluorescent substance field and making it emit light.

[Claim 5]A fluorescent substance (f) field and an intrinsic electric conduction (i) mold in the 3rd semiconductor region of low impurity concentration with the 2nd semiconductor region of low impurity concentration, and an electronic electric conduction n' (or electron hole electric conduction p') mold in the 1st semiconductor region of low impurity concentration, and an electron hole electric conduction p (or electronic electric conduction n) mold npif (or pnif) junction. an electron (or electron hole) of avalanche multiplication which is formed and is produced by pi (or ni) junction of reverse bias is direct -- an avalanche luminescent device rushing into said fluorescent substance field and making it emit light.

[Claim 6]Electronic electric conduction N' (.) which has bigger bandgap energy than the 2nd semiconductor region and said 2nd semiconductor region of low impurity concentration with a fluorescent substance (f)

field and an intrinsic electric conduction (i) mold in the 1st semiconductor region of low impurity concentration, and an electron hole electric conduction p (or electronic electric conduction n) mold Or N'pif (or P'nif) junction is formed with an electron hole electric conduction P' mold in the 3rd semiconductor region of low impurity concentration, an electron (or electron hole) of avalanche multiplication produced by pi (or ni) junction of reverse bias is direct -- an avalanche luminescent device rushing into said fluorescent substance field and making it emit light.

[Claim 7]pnf (or npf) junction is formed in the 2nd semiconductor region of low impurity concentration in the 1st semiconductor region and 2nd electric conduction (p or n) mold of low impurity concentration with a fluorescent substance (f) field and the 1st electric conduction (n or p) mold, Two-dimensional array of said pnf (or npf) junction which impressed reverse bias to pn junction and realized an avalanche multiplication process is carried out as an emission pixel, A two-dimensional avalanche luminescent device with which a transparent electrode which is a terminal of said fluorescent substance field is made into row selection lines of said emission pixel, and a metal electrode which is a terminal of said 2nd semiconductor region is characterized by having a multiplexer of a line which the selecting line of said emission pixel is carried out, and chooses said line and a selection line of a sequence, and a sequence.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application]This invention relates to an avalanche luminescent device.
[0002]
[Description of the Prior Art]EL (Electro Luminescence : electroluminescence) is proposed as a solid light emitting device for flat tip image display nearest to the principle of CRT (Cathode Ray Tube : cathode-ray tube).
[0003]The structure (a) and the energy band figure (b) of the thin film EL element (literature: Tanaka work [A vacuum, VOL.30, NO.10, 1987, PP.765-774] : "thin film electroluminescent element";) which solved low high-intensity and the low life of conventional EL are shown in drawing 6.
[0004]Drawing 6 (a) forms the transparent electrode 502 on the glass substrate 501, the 1st insulating layer 503 is formed on the transparent electrode 502, and the fluorescence layer 504 is formed on the 1st insulating layer. The 2nd insulating layer 505 is formed on the fluorescence layer 504, and, finally the back plate 506 is formed.
[0005]Although the volts alternating current of the abbreviation 200v is made to impress and emit light for this element, By the high electric field impressed to the fluorescence layer 504 like drawing 6 (b), an electron is excited from various kinds of level to a conductor, and the high electric field in a fluorescence layer accelerates, and the electron serves as the hot electron (Hot Electron), collides during a run in a luminescence center, and makes this an excitation state. It is thought that luminescence is obtained when the excited luminescence center returns to a ground state.
[0006]
[Problem(s) to be Solved by the Invention]However, in order to make light emit by the fluorescence layer 504 by which insulated separation was carried out by the insulating layers 503 and 505, very high element driver voltage is required, and quantity of the electron used as a light source cannot be controlled by the above structures. So that the hot electron which collides with a luminescence center may be called a lucky electron (LuckyElectron), Since it collides with a phonon and loses energy before most hot electrons by which it was generated in the fluorescence layer of a high electric field collide with a luminescence center (phonon scattering process), about the same sufficient luminosity

as CRT is not obtained.
[0007]This invention aims at offer of the avalanche luminescent device with which about the same sufficient light emitting luminance as CRT is obtained by low element driver voltage paying attention to the technical problem of such a conventional luminescent device.
[0008]
[Means for Solving the Problem]As for this invention, pnf (or npf) junction is formed in the 2nd semiconductor region of low impurity concentration with the 1st semiconductor region and 2nd electric conduction (p or n) mold of low impurity concentration in a fluorescent substance (f) field and the 1st electric conduction (n or p) mold, An electron (or electron hole) of avalanche multiplication produced by pn junction of reverse bias is an avalanche luminescent device which rushes into a fluorescent substance field directly and is made to emit light.
[0009]
[Function]By making it rush into a fluorescent substance field directly, reducing a phonon scattering process by the screening effect (shielding effect) of a career (an electron or an electron hole) itself [which this invention coupled directly the semiconductor region and fluorescent substance field of owner polarity, and was moreover produced in the avalanche multiplication in a semiconductor region / a lot of], moreover, a low voltage drive is possible with a simple structure of enlarging easily -- about the same bright luminescence as CRT -- it can do.
[0010]
[Example]Hereafter, the example of this invention is described with reference to drawings.
[0011]First, the principle of this invention is explained. Generally, when considering the electronic run in a solid, the speed V of the electron obtained under the electric field E is given with a following formula.
V= (qtauE/m*) {1-exp (t/tau)} -- (1), however effective mass tau of an m*:electron : Relaxation time (or mean collision time)
(1) the time of formula (t/tau)>> 1 -- the speed V -- the drift velocity Vd of a following formula -- it becomes.
Vd =qtauE/m *=muE --(2), however mu: The electric field E becomes high and electronic Vd and the linearity of the electric field E which were shown in the mobility (2) type stop materializing. If this becomes a high electric field, it will become impossible to be able to finish breathing out in a lattice the energy which the electron absorbed from the electric field by the collision with an acoustic phonon, and the dispersion (or relaxation) time tau will become short. Since it is set to electron temperature Te> lattice temperature tangent line at this time, it is called a hot electron.

[0012]If an electric field becomes still stronger, electronic energy reaches the energy of an optics type phonon and it comes to collide with this, The cause of dispersion changes from the interaction (this dispersion is dominant with nonpolar semiconductors, such as germanium and Si) to an interaction (many this dispersion is observed with the owner polar semiconductor of III-V fellows and II-VI group) with an optics type phonon with an acoustic phonon.

[0013]Since electronic energy will be substantially lost for every one collision if it becomes an interaction with an optics type phonon, the drift velocity Vd turns into the fixed saturation velocity Vds.

Vds=(omegaop/2m*) $^{1/2}$--(3), however omegaop : if the high electric field beyond the energy saturation velocity Vds field of the optics type phonon is impressed, The average energy of a conduction electron becomes larger than the generation energy of an electron and electron hole pair by electric field acceleration, the ionization by collision of the electron of a valence band is carried out to a high energy electron, it is excited to a conducting zone, and free electron and electron hole pair occur. When this is repeated, the state where it is called an avalanche effect is reached.

[0014]However, also fortunately, the electron which is not collided [an optics type phonon and] exists with the probability of a following formula. Repsiloni=exp {-epsilon i/qEdeltao} --(4), however electronic energy deltao to do the epsiloni:acceleration of: The electron which is not collided [such] is called a lucky electron for an electronic average more nearly free line. Therefore, this electron can have speed V* of the more than shown by (3) formulas (such a lucky electron is also called the electron of ballistic conduction).

[0015]The high energy which such a lucky electron has is indispensable to luminescence of a fluorescent substance.

[0016]on the other hand -- screening -- an effect -- saying -- a thing -- an electron -- a running part -- impurity concentration -- Nd -- low -- carrying out -- and -- conduction -- a career -- becoming -- an electron -- density -- ne -- high -- carrying out -- saying -- the following -- conditions -- ne -- > -- Nd -- if it becomes, dispersion will decrease [in which (5) is materialized]. In a common device, they are ne-Nd.

[0017]As mentioned above, this invention makes the lucky electron of a large number which fulfill the conditions of (5) types by avalanche multiplication of the semiconductor region of low impurity concentration, and escape a dispersion process as a result, and makes a basic principle structure where the electron can be directly rushed into a fluorescent substance field. By carrying out like this, like the luminescence process in CRT, the electron of the high energy which entered into the fluorescent substance field can excite the activator of a

fluorescent substance, emitting a secondary electron in a fluorescent substance field, and makes possible about the same bright luminescence as CRT.

[0018]The example of this invention is described concretely below. Although the owner polar semiconductor of III-V fellows and II-VI group is desirable, an example explains material using ZnSe of II-VI group.

[0019]Drawing 1 (a), (b), (c), and (d) are the 1st example of this invention.

[0020]The foundations of element structure are pnf junction which consists of ZnSe layer 102 of type, and the electron hole electric conduction (p) fluorescent substance [electronic excitation type] (f) layer 103 in the center on both sides of electronic electric conduction (n) type ZnSe layer 101 from drawing 1 (a).

[0021]If the voltage (about [10-20v] voltage) that pn junction becomes reverse bias to the both ends of the transparent electrode 105 used as the terminal electrode 104 of p type ZnSe layer 102 and the terminal electrode of the fluorescent substance layer 103 is impressed and is operated, The energy band figure of the thermal equilibrium state of drawing 1 (b) becomes like drawing 1 (c), and will be in the state which can emit light. For example, as an electron is shown in the numerals 10, when it is accelerated and the kinetic energy of 1.5 times or more of bandgap energy is obtained by an electric field, a part of the energy is given to the electron of a valence band, and it is made to ionize in a conducting zone, as shown in the numerals 112. As a result, an electron and an electron hole pair occur, and simultaneously, the 1st electron reaches the bottom of a conducting zone, as a thermal balance is reached and it is utterly shown in the numerals 111. Then, two electrons and one electron hole which may be heated by an electric field will exist. If these obtain the kinetic energy of 1.5 times or more of bandgap energy again, each will make an electron and an electron hole pair further, and will become an avalanche process. In this way, many electrons 113 by which it was generated in avalanche multiplication, The dispersion process in a semiconductor region is decreased by its screening effect, it rushes into the fluorescent substance layer 103, with the energy more than the saturation velocity usually obtained held, and a luminescence center is made into an excitation state, emitting a secondary electron in a fluorescent substance field. And as the luminescence center of an excitation state is shown in the numerals 114, when returning to a ground state, luminescence arises. The same thing is natural even if it changes n type ZnSe layer 101 into an intrinsic electric conduction (i) type ZnSe layer among the structures of this example. In this case, the junction formed turns into pif junction and reverse bias will be impressed to pi junction.

[0022]By hitting a fluorescent substance directly as mentioned above according to this example, reducing phonon scattering by the screening effect of the electron of a large number which coupled directly the semiconductor region and the fluorescent substance field, and were moreover produced in the avalanche multiplication in a semiconductor region. The same situation as the luminescence process of CRT can be realized in all the solid state components, and the voltage lowering of driver voltage and the rise in luminosity of luminescence can be realized.
[0023]Express the avalanche light emitting device of the 1st example like drawing 1 (d), arrange this to two dimensions like drawing 2, and Level and the multiplexers 160 and 170 of vertical selection, It is also possible the horizontal and vertical selecting switches 161 and 171 and to consider it as the display element for flat TV, if it is considered as the avalanche luminescent device of area using the power supply P.
[0024]Drawing 3 (a), (b), and (c) is the 2nd example of this invention. The foundations of element structure are npf junction which consists of ZnSe layer 202 of type, and the electronic electric conduction (n) fluorescent substance [electronic excitation type] (f) layer 203 in the center on both sides of electron hole electric conduction (p) type ZnSe layer 201 from drawing 3 (a).
[0025]If the voltage (about [10-20v] voltage) that pn junction becomes reverse bias to the both ends of the transparent electrode 205 used as the terminal electrode 204 of p type ZnSe layer 202 and the terminal electrode of the fluorescent substance layer 203 is impressed and is operated, The energy band figure of the thermal equilibrium state of drawing 3 (b) becomes like drawing 3 (c), and will be in the state which can emit light. For example, as an electron hole is shown in the numerals 210, when it is accelerated and the kinetic energy of 1.5 times or more of bandgap energy is obtained by an electric field, a part of the energy is given to the electron of a conducting zone, and it is made to ionize in a valence band, as shown in the numerals 212. As a result, an electron and an electron hole pair occur, and simultaneously, the 1st electron hole results in the ceiling of a valence band, as a thermal balance is reached and it is utterly shown in the numerals 211. Then, two electron holes and one electron which may be heated by an electric field will exist. If these obtain the kinetic energy of 1.5 times or more of bandgap energy again, each will make an electron and an electron hole pair further, and will become an avalanche process. In this way, the electron hole 213 of a large number generated in avalanche multiplication, The dispersion process in a semiconductor region is decreased by its screening effect, it rushes into the fluorescent substance layer 203, with the energy more than the saturation velocity usually obtained held, and a luminescence center is made into an excitation state, emitting a secondary electron

hole in a fluorescent substance field. And as the luminescence center of an excitation state is shown in the numerals 214, when returning to a ground state, luminescence arises.

[0026]The same thing is natural even if it changes p type ZnSe layer 201 into an intrinsic electric conduction (i) type ZnSe layer among the structures of this example. In this case, the junction formed turns into nif junction and reverse bias will be impressed to ni junction. it is difficult to make a p type crystal from the semiconductor of II-VI group -- it is involved -- carry out -- a direction with i type crystal will be easy to be made.

[0027]By hitting a fluorescent substance directly as mentioned above according to this example, reducing phonon scattering by the screening effect of the electron hole of a large number which coupled directly the semiconductor region and the fluorescent substance field, and were moreover produced in the avalanche multiplication in a semiconductor region. The same situation as the luminescence process of CRT can be realized in all the solid state components, and the voltage lowering of driver voltage and the rise in luminosity of luminescence can be realized.

[0028]Drawing 4 (a), (b), and (c) is the 3rd example of this invention.

[0029]The foundations of element structure are n'pnf junction which consists of ZnSe layer 302 of type and ZnSe layer 306 of an electronic electric conduction (n') mold, and the electron hole electric conduction (p) fluorescent substance [electronic excitation type] (f) layer 303 in the center from drawing 4 (a) on both sides of electronic electric conduction (n) type ZnSe layer 301. The n' type ZnSe field of this junction has an effect which makes pouring of an electron easy.

[0030]If the voltage (about [10-20v] voltage) that pn junction becomes reverse bias to the both ends of the transparent electrode 305 used as the terminal electrode 304 of n type ZnSe layer 306 and the terminal electrode of the fluorescent substance layer 303 is impressed and is operated, The energy band figure of the thermal equilibrium state of drawing 4 (b) becomes like drawing 4 (c), and an avalanche multiplication process arises and it will be in the state which can emit light.

[0031]Many electrons 313 by which it was generated in this avalanche multiplication, The dispersion process in a semiconductor region is decreased by its screening effect, it rushes into the fluorescent substance layer 303, with the energy more than the saturation velocity usually obtained held, and a luminescence center is made into an excitation state, emitting a secondary electron in a fluorescent substance field. And as the luminescence center of an excitation state is shown in the numerals 314, when returning to a ground state, luminescence arises.

[0032]The same thing is natural even if it changes n type ZnSe layer 301 into an intrinsic electric conduction (i) type ZnSe layer among the structures of this example. In this case, the junction formed turns into n'pif junction and reverse bias will be impressed to pi junction.

[0033]By hitting a fluorescent substance directly as mentioned above according to this example, reducing phonon scattering by the screening effect of the electron of a large number which coupled directly the semiconductor region and the fluorescent substance field, and were moreover produced in the avalanche multiplication in a semiconductor region. The same situation as the luminescence process of CRT can be realized in all the solid state components, and the voltage lowering of driver voltage and the rise in luminosity of luminescence can be realized.

[0034]It can be considered as the luminescent device of the same two-dimensional array type as drawing 1 (e) by expressing the avalanche light emitting device of the 3rd example of the above like drawing 4 (d), and replacing it with drawing 1 (d).

[0035]Drawing 5 (a), (b), and (c) is the 4th example of this invention.

[0036]From drawing 5 (a), the foundations of element structure, Electronic electric conduction (n) ZnSe layer 401 of type. It is the N'pnf junction which it inserts in the center and ZnSe layer 402 and bandgap energy of type become from the $Zn_{1-x}Cd_xS$ layer 406 of a bigger electronic electric conduction (N') mold than ZnSe, and the electron hole electric conduction (p) fluorescent substance [electronic excitation type] (f) layer 303. The N' type $Zn_{1-x}Cd_x$ S region of this junction makes pouring of an electron easy, and there is an effect which make an electron easy to pour in increasingly by that (like [drawing 5 (c) / of 420]) which moreover accumulates an electron hole.

[0037]If the voltage (about [10-20v] voltage) that pn junction becomes reverse bias like drawing 5 (a) to the both ends of the transparent electrode 405 used as the terminal electrode 44 of the N' type $Zn_{1-x}Cd_xS$ layer 406 and the terminal electrode of the fluorescent substance layer 403 is impressed and is operated, The energy band figure of the thermal equilibrium state of drawing 5 (b) becomes like drawing 5 (c), and an avalanche multiplication process arises and it will be in the state which can emit light.

[0038]Many electrons 413 by which it was generated in this avalanche multiplication, The dispersion process in a semiconductor region is decreased by its screening effect, it rushes into the fluorescent substance layer 403, with the energy more than the saturation velocity usually obtained held, and a luminescence center is made into an excitation state, emitting a secondary electron in a fluorescent substance field. And when the luminescence center of an excitation state returns to a ground state, as shown in the numerals 414,

luminescence arises.

[0039]The same thing is natural even if it changes n type ZnSe layer 401 into an intrinsic electric conduction (i) type ZnSe layer among the structures of this example. In this case, the junction formed turns into N'pif junction and reverse bias will be impressed to pi junction.

[0040]By hitting a fluorescent substance directly as mentioned above according to this example, reducing phonon scattering by the screening effect of the electron of a large number which coupled directly the semiconductor region and the fluorescent substance field, and were moreover produced in the avalanche multiplication in a semiconductor region. The same situation as the luminescence process of CRT can be realized in all the solid state components, and the voltage lowering of driver voltage and the rise in luminosity of luminescence can be realized.

[0041]

[Effect of the Invention]By as mentioned above, the thing for which a fluorescent substance is hit directly according to this invention reducing phonon scattering by the screening effect of the electron of a large number which coupled directly the semiconductor region and the fluorescent substance field, and were moreover produced in the avalanche multiplication in a semiconductor region. The same situation as the luminescence process of CRT can be realized in all the solid state components, and the voltage lowering of driver voltage and the rise in luminosity of luminescence can be realized.

[0042]As for the practical effect which this invention brings about, if an emission pixel is arranged to two dimensions and a multiplexer is used, it is very large to become a planar display element transposed to CRT etc.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1]It is the structure and the energy band figure 1 of an example of this invention.

[Drawing 2]It is a circuit diagram showing the circuitry which carried out two-dimensional array of the emission pixel of the example.

[Drawing 3]It is the structure and the energy band figure 2 of an example of this invention.

[Drawing 4]It is the structure and the energy band figure 3 of an example of this invention.

[Drawing 5]It is the structure and the energy band figure 4 of an example of this invention.

[Drawing 6]It is a conventional structure and energy band figure of thin film EL.

[Description of Notations]

101, 201, 301, and 401 The 1st semiconductor region

102, 202, 302, and 402 The 2nd semiconductor region

103, 203, 303, and 403 Electronic excitation type fluorescent substance field

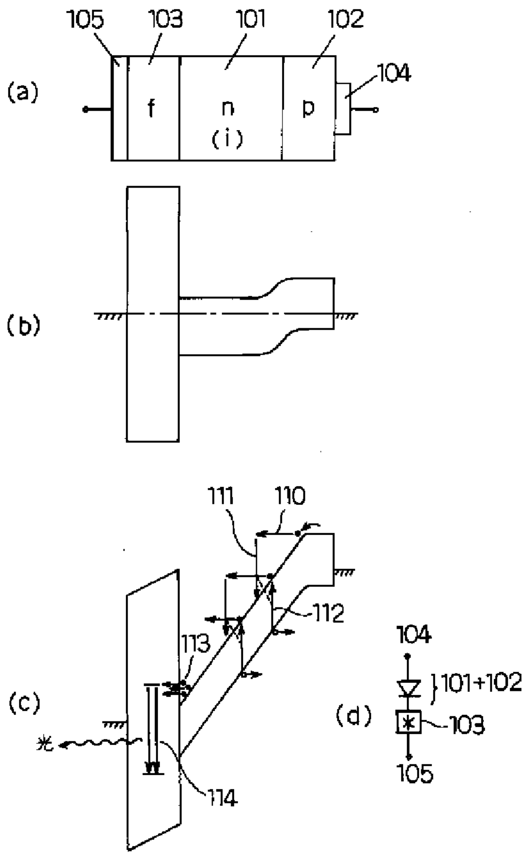
306 and 406 The 3rd semiconductor region

104, 204, 304, and 404 Metal electrode

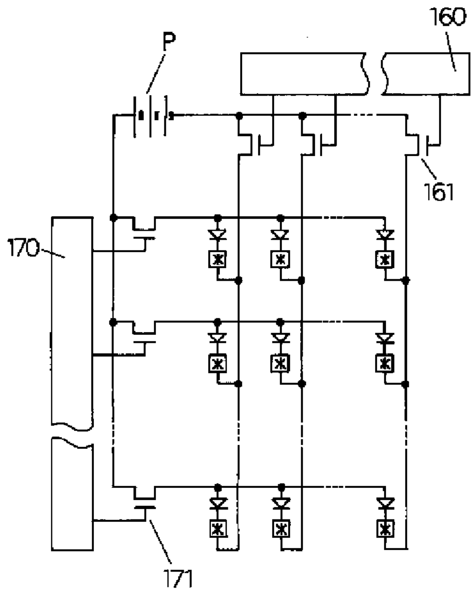
105, 205, 305, and 405 Transparent electrode

DRAWINGS

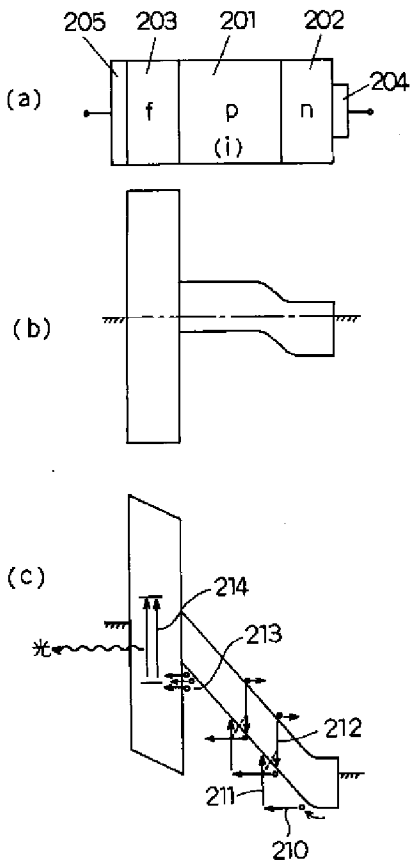
[Drawing 1]



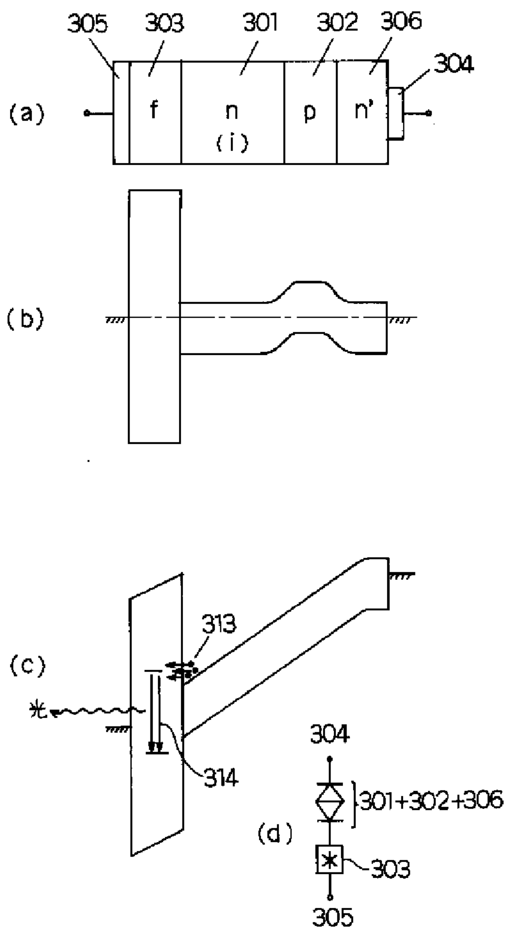
[Drawing 2]



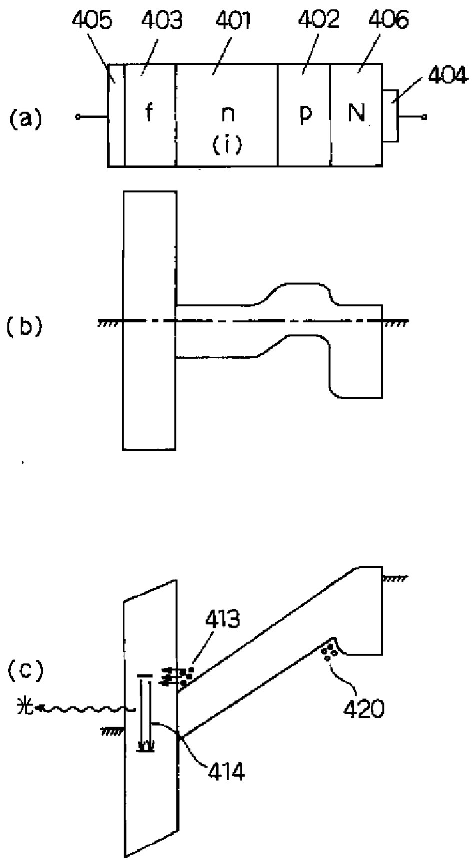
[Drawing 3]



[Drawing 4]

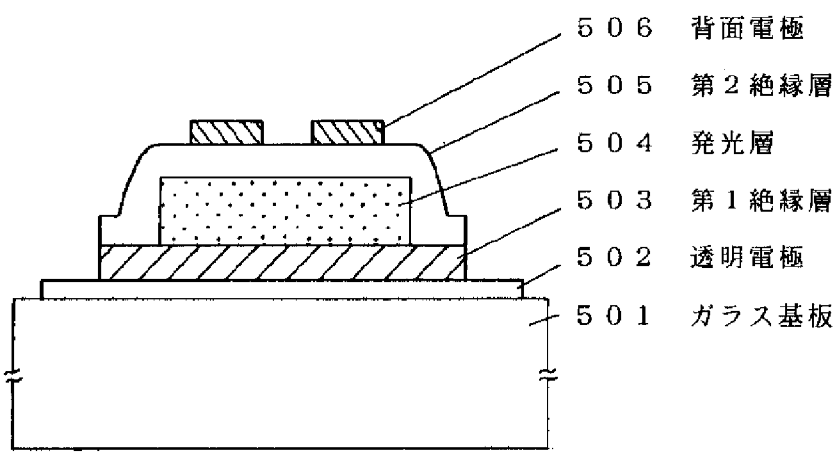

305
303
301
302
306
304
(a)
f
n
(i)
p
n'
(b)
(c)
313
光
314
304
301+302+306
(d)
303
305

[Drawing 5]



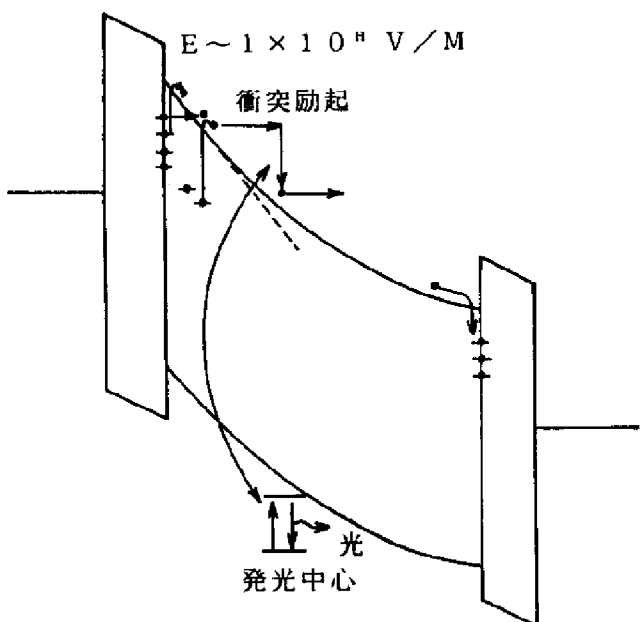
[Drawing 6]

(a)



薄膜ＥＬ素子の構造

(b)



薄膜ＥＬ素子のエネルギーバンド図